PHYTOTOXICOLOGY SURVEY ON CORNWALL ISLAND, ONTARIO: REYNOLDS METALS COMPANY (RMC), MASSENA, NEW YORK (1992)

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EXECUTIVE SUMMARY

A Federal-Provincial study with participation by several government agencies, including the Phytotoxicology Section, Ontario Ministry of the Environment, has been ongoing for several years on the Cornwall Island Indian Reservation (Mohawks of Awkwesasne). Phytotoxicology investigations, involving vegetation sampling and injury observations, to assess the impact of airborne fluoride emissions from the Reynolds Metals Company (RMC), Massena, New York, on vegetation on Cornwall Island, have been conducted during the growing season annually since 1969, except for 1988 and 1990. This report presents the results of the most recent survey on Cornwall Island conducted in August 1992.

In 1992, the sampling of the regular maple foliage sites and inspections of vegetation for fluoride injury were performed only in August. The monthly forage collection program between May and October was discontinued because of budget and manpower constraints. The Environment Canada ambient fluoride and wind monitoring program on Cornwall Island also was discontinued in 1992.

In 1992, the highest degree of foliar contamination and most severe vegetation injury was observed in the vicinity of the south shore bridge area, as in previous years. Fluoride concentrations in maple foliage were generally reduced from 1991 results and were amongst the lowest to be detected since the survey began.

The rural Upper Limit of Normal (ULN) guideline for fluoride in tree foliage (15 ug/g) was exceeded at eight sites. The fluoride concentration at the most contaminated maple foliage Site 1 (135 ug/g), situated in the south shore bridge area, was several times higher than the 15 ug/g rural ULN.

Inspections in August (1992) revealed no major change in the degree and extent of fluoride-type foliar injury from the previous year, with there being a slight reduction in injury overall in 1992.

Weather conditions, together with an earlier collection date, likely contributed to the reduction in contamination of vegetation on Cornwall Island in 1992 from recent peak values in 1991. RMC emissions also may have been reduced but this has not been verified as ambient fluoride monitoring on the island was not conducted by Environment Canada in 1992.

PHYTOTOXICOLOGY SURVEY ON CORNWALL ISLAND, ONTARIO: REYNOLDS METALS COMPANY (RMC), MASSENA, NEW YORK (1992)

INTRODUCTION

Vegetation assessment surveys on Cornwall Island in Ontario, in the vicinity of the Reynolds Metals Company (RMC), Massena, New York, have been conducted by the MOE Phytotoxicology Section during the growing season each year since 1969, with 1988 and 1990 being the only exceptions. The vegetation assessment program is part of an ongoing joint Federal-Provincial study that was established in 1975, with participation by Environment Canada, Agriculture Canada, National Health and Welfare, Indian and Northern Affairs and the Ontario Ministry of the Environment. Prior to 1975, the Phytotoxicology Section had been conducting annual vegetation surveys and responding to complaints concerning the adverse effects of airborne fluoride emissions on vegetation and cattle on Cornwall Island since 1969. The source of the fluoride emissions was identified as the Reynolds Metals Company (RMC), located in Massena, New York. The study was broadened in 1975 in view of the transboundary nature of the emissions and their impact on the Awkwesasne Mohawk Indian Reserve on Cornwall Island. The primary objective of the 1992 Phytotoxicology program, similar to previous years, was to determine the degree and extent of fluoride contamination and injury to vegetation on Cornwall Island and to compare these findings with previous years' results. The results for all previous Phytotoxicology vegetation assessment programs through to 1991 have been previously reported.

VEGETATION ASSESSMENT PROGRAM (1992)

Visual Inspections / Samples for Chemical Analysis

In 1992, a single-visit survey was conducted in August. Vegetation on Cornwall Island was inspected for fluoride injury and maple foliage was sampled at established sites across the island. The monthly forage collection program conducted in previous years between May and October was discontinued because of budget and manpower constraints.

As in previous surveys, vegetation (cherry, maple, sumach, pine, wild and cultivated grape, gladiolus, vegetable crops etc.) was inspected for foliar fluoride injury at sites immediately north and northeast of RMC, as well as at more remote locations on Cornwall Island.

In addition, foliage was collected from exposed middle branches at the ten Manitoba maple tree sites (1, 2, 3, 6, 7, 8, 9, 20, 21, 33), and at the three red maple sites (south

shore west of bridge, south shore east of bridge, and N. Point), that were sampled in previous years on Cornwall Island. Duplicate samples at each site were collected using standard sampling procedures. The red maple in the west woodlot was situated about 100 m west of Manitoba maple Site 21, while the red maple in the east woodlot was situated about 50 m east of Manitoba maple Site 1 (see Figure 1).

The foliage samples were returned to the Phytotoxicology processing laboratory, where they were processed as "unwashed" samples (oven-dried, ground and stored in glass jars). They were then submitted to the MOE Laboratory Services Branch for analysis of fluoride, aluminum and sodium.

Samples Collected for Histological Examination

In 1992, current year needles with reddish tip necrosis were collected from a young Eastern white pine near maple Site 3. The needles were stored in preserving fluid and returned to the Phytotoxicology Laboratory for examination by the Section Histopathologist.

RESULTS OF VEGETATION ASSESSMENT PROGRAM (1992)

Visual Findings

On Cornwall Island in August (1992), fluoride-type foliar injury on vegetation was largely confined to the vicinity of the south shore bridge area, directly downwind and northeast of RMC. This area includes residential areas in the vicinity of the Martin, A. Boots and N. Point properties (see Figure 1).

In the south shore bridge area, well-exposed wild grape plants beside the river had trace (<0-1%) to light (2-10%) injury overall, with the most severe injury (light overall) being observed just east of the bridge. Also, close to the river but to the west of the bridge, fluoride-type injury of light (2-10%) to moderate (11-35%) severity overall was observed on a young black cherry tree. A young serviceberry tree in the same general area had light injury overall. As in previous surveys, mature staghorn sumachs in the vicinity of the river (east and west of bridge) had foliage that was distinctly savoyed (wrinkled) or cupped and with marginal and interveinal necrosis. Sumachs just west of the bridge had moderate (11-35%) to severe (>35%) injury overall, with the injury on other affected sumachs in the vicinity of the bridge being light, or light to moderate, overall.

The injury on staghorn sumach (usually considered as intermediate in sensitivity to fluoride) was unusual and appeared too severe and out of context relative to the condition of other vegetation, including pin and choke cherry trees, plum trees, and sensitive indicators such as wild grape, Manitoba maple and Eastern white pine, to be entirely due to fluoride. However, as sumachs remote from RMC were in normal healthy condition, and the sumach injury was most severe and extensive in the area where foliar injury was

most pronounced on other species, the possibility that RMC emissions had contributed to the sumach injury can not be ruled out. Moreover, the observations in the south shore area revealed a few leaves with trace fluoride-type injury on a few pin cherry trees, as well as on Manitoba maple (Site 1) and at the two red maple sites in the south shore area. Fluoride injury was not observed on plum trees (plot west of bridge), but as in previous years, both plum and cherry trees in the south shore area had leaves with missing marginal tissue symptomatic of exposure to fluoride. Inspections of Eastern white pine in the south shore area woodlots (east and west of bridge) did not reveal any obvious fluoride-type injury on current year needles.

Inspections of vegetation, including wild and cultivated grape, plum, maples, pines and garden crops, also were conducted on residential properties (Martin, V. Jacobs, L. Point, N. Point, A. Boots, G. Charrow) in the slightly more remote areas northeast and north of RMC (see Figure 1). Fluoride-type marginal leaf necrosis of trace severity overall was observed on Manitoba maple at L. Point, on cultivated grape at A. Boots and on gladiolus at N. Point. With the exception of wild grape, other vegetation that was examined on residential properties in the vicinity of the south shore bridge area was judged to be in normal condition, including garden crops and pine trees (red, Scots) on the L. Point and the N. Point property (A. Boots and G. Charrow had no garden in 1992).

On extremely sensitive wild grape foliage, fluoride-type injury of trace to light severity was observed through to the vicinity of the former N. Point forage site which was situated about 2 km northeast of RMC. The inspections of wild and cultivated grape more distant from RMC, including sites near the center and east end of the island (Elijah Benedict, Earny Benedict, A. Lazore), revealed either no injury or only terminal (tip) injury that was inconsequential. Inspections on other vegetation beyond the south shore bridge area through to the vicinity of A. Lazore (east end of island) also did not reveal any injury that was attributable to fluoride. An exception was a young Eastern white pine near maple Site 3. This pine had fluoride-type tip injury on several current year needles, but the results of the histological examination indicated that fluoride was not involved.

The observations in the south shore bridge area in August 1992 are compared to the 1991 injury ratings in Table 7. Compared to 1991, the severity of fluoride-type injury on foliage of sensitive wild grape plants and other vegetation on Cornwall Island was, with few exceptions, similar to 1991 or slightly reduced in 1992.

Analytical Results

Fluoride

The fluoride results for the Manitoba maple sites are compared with previous survey data in Table 1 (1980-1992) and Table 2 (1972-1979). The line graph (Figure 2) on the following page compares the fluoride level at Site 1 (closest to RMC) with the overall mean of common sites for the surveys since 1980.

In August 1992, the fluoride results for the Manitoba maple sites had a pattern similar to previous surveys - foliar concentrations were highest at Site 1 (135 ug/g) in the south shore bridge area and sharply decreased with increasing distance from RMC. In 1992, the fluoride concentration at seven of the ten Manitoba maple sites was lower than in 1991, especially at Site 1. The August fluoride level at Site 1 (135 ug/g) was less than half of the corresponding 1991 level (375 ug/g) and was the lowest value recorded at this site. The fluoride mean for 1992 (31 ug/g) also was the lowest detected since 1980. The red maple at the three sample sites also contained lower fluoride concentrations overall in 1992 than in 1991, with levels at the east bridge site (57 ug/g) and N. Point site (34 ug/g) also being amongst the lowest detected since 1982 (Table 5).

In 1992, foliage from five of the ten Manitoba maple sites in August exceeded the Phytotoxicology Section rural Upper Limit of Normal (ULN) guideline of 15 ug/g. Five sites also exceeded the rural ULN in 1991 and 1989. The three red maple sites also exceeded the rural ULN, as in previous years.

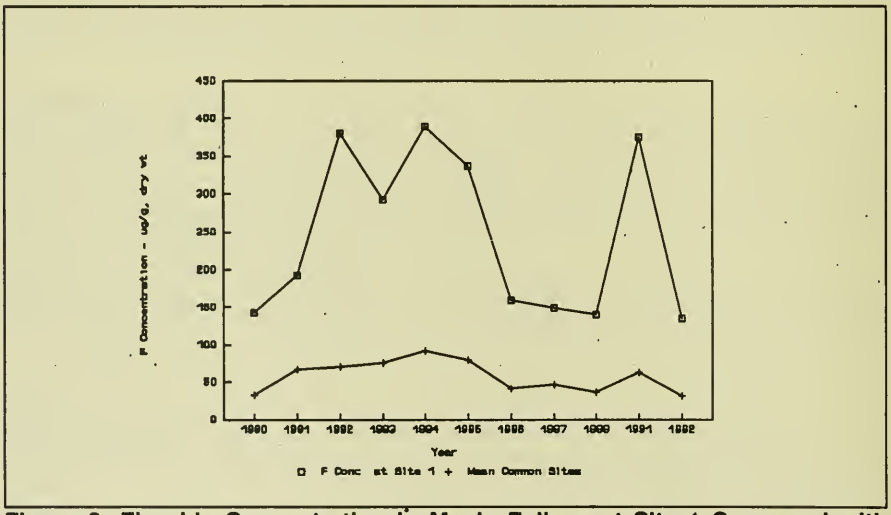

Figure 2: Fluoride Concentration in Maple Foliage at Site 1 Compared with Mean of Common Sites in August: 1980 to 1992

Aluminum and Sodium

The aluminum and sodium results are compared to previous survey data in Tables 3 and 4, respectively. Figures 3 and 4 (page 18) show the respective aluminum and sodium

results at Manitoba maple Site 1, as well as the corresponding mean of all common Manitoba maple sites for each year since 1980. As with fluoride, Site 1 in the south shore bridge area had the highest foliar concentrations of aluminum and sodium. Foliar levels of both elements sharply decreased with increasing distance from RMC.

In 1992, the concentration of aluminum at most Manitoba maple sites was slightly increased compared to 1991. The concentration of aluminum at Site 1 (420 ug/g) was the highest recorded on Cornwall Island. The foliar concentration at Site 21 (165 ug/g) also was the highest recorded since this site was first sampled in 1986. However, the mean of all common sites in 1992 (107 ug/g) was similar to 1991 (109 ug/g), with higher means being found in previous surveys. Since 1980, the aluminum mean for common Manitoba sites in August has ranged between 44 (1989) and 145 ug/g (1980), as shown in Figure 3. In 1992, similar to previous years, even the highest aluminum value did not exceed the rural ULN of 500 ug/g.

As with fluoride, concentrations of sodium at Manitoba maple Site 1, as well as at several other Manitoba maple sites, were lower in 1992 than in 1991. The means for these years showed a similar trend, with the August mean for 1992 (74 ug/g) being amongst the lowest. Since 1980, the August mean of all common Manitoba sites has ranged from a low of 65 ug/g (1987) to a high of 165 ug/g (1982), as illustrated in Figure 4. In 1992, the rural ULN for sodium (50 ug/g) was exceeded at seven of the ten Manitoba maples sites. This compares to eight sites in 1991, 1989 and 1987. In 1992, the elevated sodium concentration at Site 1 (250 ug/g) was four times higher than the rural ULN.

Table 6 shows the aluminum and sodium results for the three red maple sites in August 1992 compared to 1991. In both years, foliar levels of both elements were the highest at the east of bridge site, immediately northeast of RMC. In 1992, concentrations of aluminum were reduced at two of the three sites, particularly at the east of bridge site. However, the ULN of 500 ug/g was not exceeded. The level of sodium at all red maple sites was similar to 1991, and only the site east of the bridge exceeded the rural ULN (50 ug/g), as in 1991.

Results of Histological Examination

Results of the histological examination of the sample of injured current year Eastern white pine needles revealed no injury typical of fluoride.

METEOROLOGICAL ASPECTS (1992)

In 1992, the monitoring of ambient fluoride and of wind direction/speed on Cornwall Island was discontinued by Environment Canada. Wind monitoring at the Ontario Hydro climate station (west of Cornwall) also was discontinued. According to staff of the Environment Canada Ontario Climate Center, the wind instrument at the Ontario Hydro station has not been properly maintained for some time because of unsafe conditions and the wind data

from 1985 and subsequent years is questionable. Precipitation collection is still carried out daily at this station.

The wind data shown in Table 9 below was obtained from the Airport at Massena, New York, just across the river from Cornwall Island. This table shows the percentage of time the prevailing wind was from the south and southwest during June through August in 1991 and 1992. Wind from these directions is primarily responsible for carrying RMC emissions onto Cornwall Island. Table 9 shows that, in spite of the earlier vegetation collection date in 1992 (Aug. 11 versus Aug. 22 in 1991), the relative amount of south, south southwest, southwest, and west southwest wind that the survey area had been exposed to over the shorter period in 1992 (32.5%) was slightly increased from 1991 (29.1%).

Table 9: Percentage (%) of Time the Prevailing Wind was from South and Southwest Directions at Massena Airport during June to August*, 1991 & 1992.

Direction	1991	1992
S	0.8	1.1
SSW	1.3	2.3
SW	6.4	6.2
WSW	20.5	22.9
Total above wind	29.1	32.5

* From June through to and including date of foliage collection: 1991 - Aug. 22; 1992 - Aug. 11

Within limits, rain can also influence fluoride concentrations in vegetation. Rain can remove fluoride, especially of the particulate type, through foliar rinsing. Rain-washed foliage could be a factor in this survey because RMC emits sodium aluminum fluorosilicate as a particulate, in addition to gaseous hydrogen fluoride. This washing action can be reflected in the analytical results wherein years with high rainfall should have lower fluoride concentrations if other factors are held constant. Conversely, dry years should be associated with higher fluoride values. Table 8 summarizes the rainfall data for the Ontario Hydro Station, Cornwall, and shows that July of 1992 was amongst the wettest recorded, with fifteen days receiving rain compared to the norm of eleven. There were eight days with rain over the two week period prior to the August 1992 foliage collection, which was conducted about two weeks earlier than in previous years. The wet conditions in July, together with the earlier collection date in 1992, likely contributed to the decrease in vegetation fluoride concentrations on Cornwall Island in 1992. A reduction in emissions from RMC (not confirmed) also would result in reduced fluoride concentrations in vegetation.

SUMMARY OF 1992 SURVEY FINDINGS

The main findings of the 1992 survey on Cornwall Island can be summarized as follows:

1) RMC emissions during 1992 resulted in elevated levels of fluoride, aluminum and sodium in vegetation, particularly in the south shore bridge area (northeast of RMC), with the highest levels in August being found at Manitoba maple Site 1 just east of the bridge. Fluoride levels in vegetation, as in previous years, displayed a decreasing pattern with increasing distance from RMC.

2) Fluoride levels in maple foliage in 1992 were generally decreased from 1991 and were amongst the lowest recorded. This was likely due, in part, to the earlier collection date in 1992 and a higher than normal precipitation in the month prior to the collection. Sodium levels in August also were decreased overall compared with 1991, but aluminum levels were increased from 1991 levels particularly at Site 1, which was closest to the northeast of RMC.

3) The reduction in foliar contamination by fluoride and sodium in 1992 coincided with a slight reduction overall in the number of exceedances of the Phytotoxicology foliage guidelines. In 1992, the rural ULN for fluoride (15 ug/g) was exceeded at a total of eight sites, as in 1991 and 1989. Eight maple sites also exceeded the rural ULN for sodium (50 ug/g) in 1992, compared to nine sites in 1991. Forage sampling was not conducted in 1992.

4) Fluoride-type injury on deciduous vegetation was generally confined to the south shore bridge area of Cornwall Island. There was no major change in injury from 1991, with the degree and extent of fluoride-type injury being slightly reduced overall in 1992.

In conclusion, concentrations of fluoride in vegetation on Cornwall Island in 1992 were amongst the lowest detected and were reduced from recent peak 1991 levels. The lower levels in 1992 were accompanied by a slight reduction in the degree and extent of vegetation injury. As in previous years, the highest degree of foliar contamination and most adverse vegetation injury was confined to the south shore bridge area to the northeast of RMC. The earlier collection date in 1992, together with a wetter than normal July, likely contributed to the reduction of fluoride contamination of vegetation in 1992.

Table 1: Concentrations of Fluoride in Manitoba Maple Foliage on Cornwall Island: August 1980 - 1992

Site No.	Kilometers & Direction from RMC	Concentration* in Unwashed Foliage										
		1980	1981	1982	1983	1984	1985	1986	1987	1989	1991	1992
1	1.5 NE	143	192	380	293	389	337	159	149	140	375	135
33	1.9 NE	NR	NR	NR	123	117	71	49	48	55	78	47
3	3.1 NE	60	86	70	97	113	92	48	59	51	41	26
6	4.1 NE	23	71	28	48	57	48	25	44	15	29	26
7	6.8 NE	15	64	15	37	39	33	18	24	13	14	15
21	1.3 NNE	NR	NR	NR	NR	NR	NR	69	74	76	93	70
2	2.0 NNE	10	50	25	57	63	50	27	48	35	14	15
8	1.9 N	8	18	12	27	23	32	19	18	10	7	11
9	2.5 N	5	26	18	19	14	22	17	14	8	9	6
20	6.1 ENE	3	29	17	31	41	26	19	22	15	15	10
Mean Common Sites**		33	67	71	76	92	80	42	47	36	63	31

* ug/g, dry weight, mean of duplicate (1987 to 1992) or triplicate (1983 to 1986) samples. Single samples were collected from 1980 to 1982.

** Mean of common sites for all years, excluding Sites 21 and 33

NR - No results, samples not collected/analysis not conducted

Note a: Values underlined exceed Phytotoxicology Section Upper Limit of Normal (ULN) rural guideline of 15 ug/g (see appendix)

Note b: Samples have been analyzed by ion selective electrode since 1982. Alkali fusion method was used in previous years

Table 2: Concentrations of Fluoride in Manitoba Maple Foliage on Cornwall Island in August: 1972 - 1979

Site No.	Kilometers & Direction from RMC	Concentration* in Unwashed Foliage							
		1972	1973	1974	1975	1976	1977	1978	1979
1	1.5 NE	451	597	516	1171	550	750	193	197
33	1.9 NE	NR	NR	NR	NR	NR	NR	NR	NR
3	3.1 NE	NR	NR	NR	NR	122	217	32	57
6	4.1 NE	317	244	98	235	114	56	22	32
7	6.8 NE	90	NR	79	100	116	37	23	21
21	1.3 NNE	NR	NR	NR	NR	NR	NR	NR	NR
2	2.0 NNE	NR	NR	NR	NR	123	138	17	31
8	1.9 N	30	NR	76	60	29	45	15	21
9	2.5 N	NR	NR	NR	66	31	14	7	15
20	6.1 ENE	NR	NR	NR	NR	NR	NR	6	15

* ug/g, dry weight, mean of triplicate results (1975-1979), or a single sample collected (prior to 1975).
NR - No result, samples not collected/analysis not conducted
Note: Values underlined exceed Phytotoxicology Section rural ULN of 15 ug/g (see appendix)
Note: Alkali fusion method was used in these years

Table 3: Concentrations of Aluminum in Manitoba Maple Foliage on Cornwall Island: August 1980-1992

Site No.	Distance (km) & Direction from RMC	Concentration* in Unwashed Foliage										
		1980	1981	1982	1983	1984	1985	1986	1987	1989	1991	1992
1	1.5 NE	346	190	174	181	193	217	127	101	91	390	420
33	1.9 NE	NR	NR	NR	131	130	62	45	72	70	115	130
3	3.1 NE	120	101	74	99	107	84	47	62	57	66	77
6	4.1 NE	86	125	32	79	69	78	22	67	27	67	85
7	6.8 NE	314	334	70	110	103	137	41	77	35	95	100
21	1.3 NNE	NR	NR	NR	NR	NR	NR	29	76	45	84	165
2	2.0 NNE	106	146	96	128	83	90	47	185	68	75	57
8	1.9 N	58	68	51	96	57	115	35	67	31	73	41
9	2.5 N	40	52	49	66	26	58	28	58	13	35	20
20	6.1 ENE	96	73	80	110	81	74	27	51	35	73	57
Mean Common Sites		145	136	78	108	89	106	46	83	44	109	107

* ug/g, dry weight, mean of duplicate (1987 to 1992) or triplicate (1983 to 1986) samples. Single samples were collected in 1980 to 1982
NR - No results, samples not collected/analysis not conducted
Note: Phytotoxicology Section Upper Limit of Normal rural guideline is 500 ug/g, see appendix

Table 4: Concentrations of Sodium in Manitoba Maple Foliage on Cornwall Island: August 1980-1992

Site No.	Distance (km) & Direction from RMC	Concentration* in Unwashed Foliage										
		1980	1981	1982	1983	1984	1985	1986	1987	1989	1991	1992
1	1.5 NE	460	202	520	373	480	420	137	105	275	325	250
33	1.9 NE	NR	NR	NR	253	287	160	110	81	145	120	145
3	3.1 NE	220	180	245	157	223	143	84	88	100	105	81
6	4.1 NE	123	137	112	107	109	100	65	61	40	65	78
7	6.8 NE	104	90	48	67	95	89	48	36	64	50	51
21	1.3 NNE	NR	NR	NR	NR	NR	NR	117	99	205	180	140
2	2.0 NNE	80	93	132	70	85	81	69	91	73	59	27
8	1.9 N	90	70	85	77	68	64	39	57	70	66	34
9	2.5 N	75	73	125	43	61	34	35	36	23	36	19
20	6.1 ENE	77	90	53	77	99	105	74	52	58	56	56
Mean Common Sites		153	116	165	121	152	129	68	65	87	95	74

* ug/g, dry weight, mean of duplicate (1987 to 1992) or triplicate (1983 to 1986) samples and analysis. A single sample per site was collected in 1980 to 1982

NR - No result, samples not collected/analysis not conducted

Note: Values underlined exceed Phytotoxicology Section rural ULN of 50 ug/g, see appendix

Table 5: Concentrations of Fluoride in Red Maple Foliage on Cornwall Island in August: 1982 to 1992

Location	Concentration* in Unwashed Foliage										
	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
South Shore Woodlot											
- West of Bridge	118	NR	134	22	37	59	NR	48	NR	34	39
- East of Bridge	99	NR	278	139	43	109	NR	64	NR	195	57
More Remote											
- N. Point	NR	NR	172	88	42	81	NR	44	NR	62	34

* ug/g, dry weight, mean of triplicate (1984) or duplicate (1985-1992) samples. Single samples were collected in 1982
ND - No result, samples not collected/analysis not conducted
Note: Values underlined exceed Phytotoxicology Section rural ULN of 15 ug/g, see appendix

Table 6: Foliar Concentrations* of Aluminum and Sodium at Red Maple Sites on Cornwall Island in August: 1991 and 1992

Location	Aluminum		Sodium	
	1991	1992	1991	1992
South Shore Woodlot				
- West of Bridge	79	100	28	35
- East of Bridge	225	130	57	60
More Remote				
- N. Point	95	74	36	34
Rural ULN	**500**		**50**	

* ug/g, dry weight, mean of duplicate samples and analysis
Note: Values underlined exceed rural ULN, see appendix

Table 7: Fluoride-Type Injury Observed in Vicinity of South Shore Bridge Area in August: 1991 and 1992

Species	Description of Foliar Injury	Area(s) Injury Observed	Injury Overall[3]	
			1991	1992
Black Cherry	Reddish-brown necrosis tips/margins several leaves	Near River (1) Woodlot Area (2)	L NE	L-M H
Pin Cherry	Tan to reddish necrosis tips/margins some leaves	Woodlot Area (1) River Area (1) River Area (2)	T-H T T	H T H
Manitoba Maple	Reddish-tan necrosis tips/margins some leaves	Site 1 (2) Site 33 (2) L. Point (2)	L-M T *T-L	T H T
Red/Silver Maple	Blackish necrosis tips/margins some leaves	Woodlot (1) Woodlot (2) N. Point (2) A. Boots (2)	T L T T	T T H T
Plum	Red-brown necrosis tips/margins some leaves	L. Point (2)	*T-L	H
Serviceberry	Red-brown marginal necrosis & cupping several leaves	River Area (1)	T-L	L
Staghorn Sumach**	Red-brown to black necrosis tips/margins some leaves, leaves wrinkled (savoyed), cupped, or broken edges	Plum Plot Area (1) Woodlot Area (1) River Area (1) Woodlot Area (2) River Area (2)	*T-L L T-L NE L-M	L-M L L-S L T-M
Wild Grape	Reddish-brown necrosis tips/margins some leaves	Woodlot area (1) River Area (1) Woodlot Area (2) River area (2) N. Point (2) A. Boots Area (2) Customs Area (1)	T-L L T-L *T-L T-L T-L T	T-L T-L T L T T T-H
Cultivated Grape	Reddish necrosis tips/margins some leaves	A. Boots (2)	T	T
Gladiolus	Reddish necrosis tips/margins some leaves	N. Point (2)	T	T

* Injury Rating in July. ** 1991 rating reflects degree of necrosis, whereas 1992 rating reflects total severity (necrosis + savoying etc.)
NE - Not examined in July or August
1 - Immediate impact area neighbouring to west of International Bridge
2 - Impact area neighbouring to east of Bridge
3 - Fluoride-type necrosis: H-Healthy; T-Trace 0-1%; L-Light 2-10%; M-Moderate 11-35%; S-Severe >35%

Table 8: Total Precipitation and Number of Days with Rain at Ontario Hydro Climate Station, Cornwall: June through August 1981-1992

Year	JUNE		JULY		AUGUST		JUNE-AUGUST*	
	Total	Freq.	Total	Freq.	Total	Freq.	Total	Freq.
1981	95	14	69	8	122	16	382	50 (5)
1982	86	14	66	10	125	12	324	42 (8)
1983	79	11	92	11	61	8	317	46 (4)
1984	55	8	51	11	95	14	296	47 (7)
1985	148	18	68	11	70	9	336	48 (6)
1986	108	13	165	14	104	16	466	60 (7)
1987	82	18	111	15	98	15	314	57 (6)
1989	99	13	73	6	108	15	370	54 (6)
1991	27	3	49	12	125	12	267	37 (8)
1992	64	14	117	15	57	17	214	36 (8)
Norms**	70	11	76	11	99	11	NA	NA

* June through to and including date of regular maple foliage collection: 1981-Aug 26; 1982-Aug 25; 1983-Aug 23; 1984-Aug 23; 1985-Aug 28; 1986-Aug 27; 1987-Aug 18; 1989-Aug 22; 1991-Aug 22; 1992-August 11.

** Rainfall normals taken from Canadian Climate Normals, Atmospheric Environment Service, Environment Canada, Toronto

( ) Number of days with rain during two week period prior to date of foliage collection

NA - Not available

Note: July 1992 data from station in Cornwall

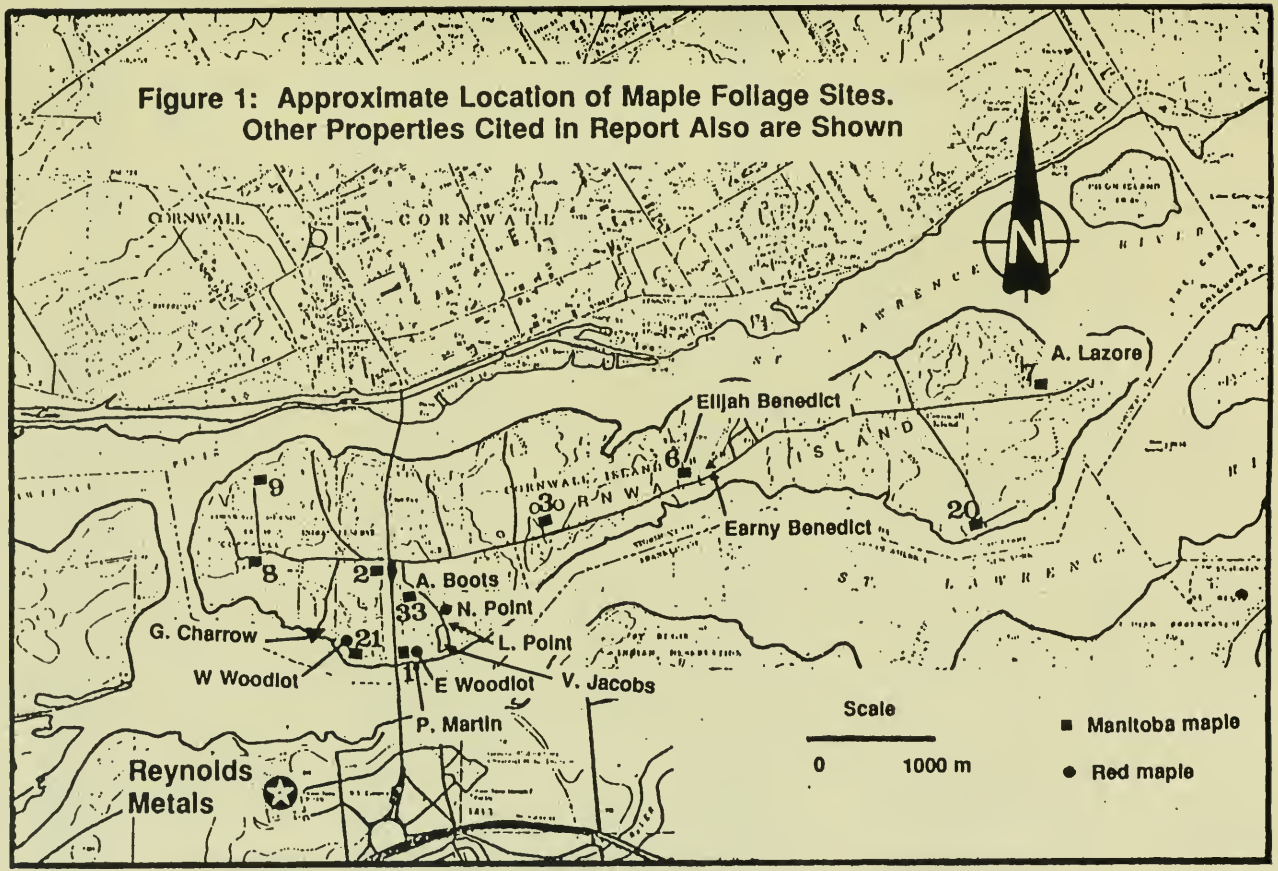
Figure 1: Approximate Location of Maple Foliage Sites.
Other Properties Cited in Report Also are Shown
CORNWALL
CORNWALL
N
A. Lazore
Elijah Benedict
Earny Benedict
CORNWALL ISLAND
ST. LAWRENCE
9
8
2
A. Boots
33
N. Point
G. Charrow
21
L. Point
W Woodlot
1
E Woodlot
V. Jacobs
P. Martin
Reynolds Metals
6
30
20
Scale
0
1000 m
Manitoba maple
Red maple

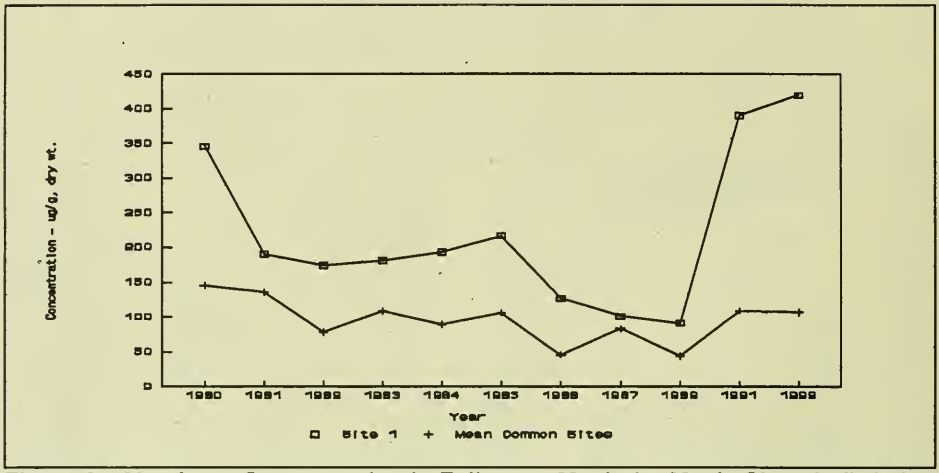

Figure 3: Aluminum Concentration in Foliage at Manitoba Maple Site 1 in Relation to Overall Mean of Common Sites for Years Since 1980

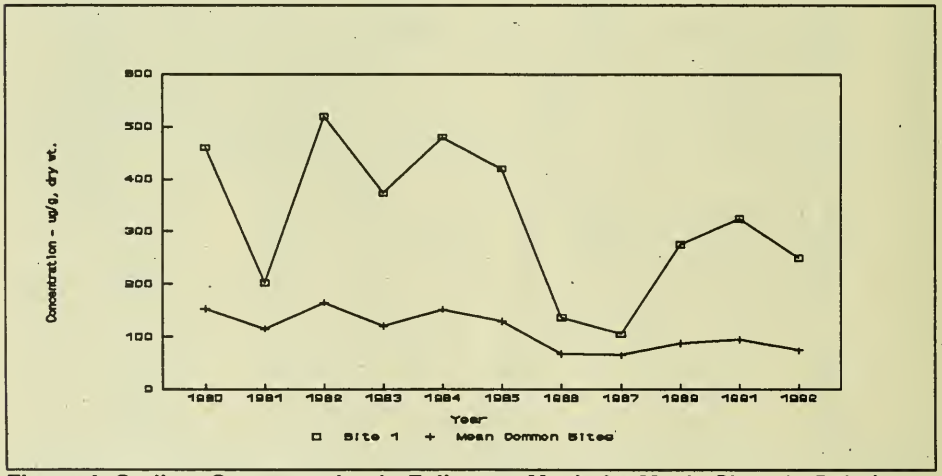

Figure 4: Sodium Concentration In Foliage at Manitoba Maple Site 1 in Relation to Overall Mean for Common Sites for Years Since 1980

APPENDIX

Derivation and Significance of the MOE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines.

The MOE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a pollution source. Urban ULN guidelines are based on samples collected from urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (reference: Ontario Ministry of the Environment 1992, *Phytotoxicology Field Investigation Manual).* Chemical analyses were conducted by the MOE Laboratory Services Branch.

The ULN is the arithmetic mean plus three standard deviations of the suitable background data for each chemical element and parameter. This represents 99% of the sample population. This means that for every 100 samples that have not been exposed to a pollution source, 99 will fall within the ULN.

The ULNs do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULNs are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULNs are not known to be toxic.

ULNs are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULNs. The MOE Phytotoxicology ULNs are constantly being reviewed as the background environmental data base is expanded. This will result in more ULNs being established and may amend existing ULNs.